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Decision Support for Emergency Management

From the Nordic Project "NKA/INF: Information Technology for Accident and Emergency Management", to the European Project "IT Support for Emergency Management – ISEM"

The INF-group concerning the Nordic project and
the ISEM-group concerning the European project

prepared by project manager
V. Andersen, Risø National Laboratory

Risø National Laboratory, DK-4000 Roskilde, Denmark
May 1989

Risø-M-2788

DECISION SUPPORT FOR EMERGENCY MANAGEMENT

From the Nordic Project "NKA/INF: Information Technology for Accident and Emergency Management", to the European Project "IT Support for Emergency Management - ISEM"

The INF-group concerning the Nordic project and the ISEM-group concerning the European project

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ABSTRACT

A short introduction will be given to the Nordic project "NKA/INF: Information Technology for Accident and Emergency Management", which is now in its final phase. To perform evaluation of the project, special scenarios have been developed, and experiments based on these will be fulfilled and compared with experiments without use of the decision support system.

Furthermore, the succeeding European project, "IT Support for Emergency Management - ISEM", with the purpose of developing a decision support system for complex and distributed decision making in emergency management in full scale, will be described and the preliminary conceptual model for the system will be presented.

May 1989
Risø National Laboratory, DK-4000 Roskilde, Denmark

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- The Nordic NKA/INF project accomplished by the INF-group, and
- The European, ESPRIT II project accomplished by the ISEM-group.

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INTRODUCTION

There is an increasing potential for severe accidents as the industrial development tends towards large, centralised production units. In several industries this has led to the formation of large organisations which are prepared for accident fighting and emergency management (EM). The functioning of these organisations critically depends upon efficient decision making and exchange of information.

Experience has shown that operators may take precipitate action during the stress of an emergency situation. Based on detailed analysis of drills and accidents at risky industrial plants, needs for and assessments of development of an on-site decision support system for operators and utilities have been unveiled.

Similarly, full-scale emergency drills have been used to look into the flow of information between different participants or organisational units within the off-site emergency organisations to unveil needs and assessments to support authorities in protection of people and environment in the vicinity of a risky industrial plant.

The Nordic project is aimed at securing and possibly improving the functionality and efficiency of accident and emergency management by verifying, demonstrating, and validating the possible use of advanced information technology in the organisations mentioned above.

Prototype systems covering limited parts of an accident and emergency situation have been developed to demonstrate the potential use of computer and communication systems, data base and knowledge base technology, and applications of methods used in artificial intelligence.

The end product will be production of guidelines for the introduction of advanced information technology in the organisations based on evaluation and validation of the prototype systems.

Experience gained from these systems should decide as to what extent the use of information technology will be realistic, considering the time-, personnel-, and other resources that are to be spent in connection with developing a total preparedness system.

The main objective of **the European project** is to describe architectures and generate a set of accompanying software tools in relation to an integrated information system to support complex, dynamic, distributed decision making in large organisations, and to demonstrate the functionality of a full-scale system for emergency management.

Furthermore, the project will involve:

- The exploration, development, and description of architectures for decision support systems suited for emergency management of rare but severe events in large organisations.

- The development of tools supporting system specification and design, knowledge acquisition, system development, and maintenance throughout the full life cycle of the system.

- The design implementation, test, and evaluation of two demonstration systems.

- Demonstration of the operation and maintenance of the decision support system.

- Development of guidelines and strategies for the proper use of the project results in a variety of industrial sectors.

So, as the latter project may be seen as a successor to the first one, they differ in the sense that the Nordic project aims at demonstrating the validity of using modern information technology in emergency management, whereas the European project aims at developing an integrated information system in full-scale for emergency management in complex industrial establishments.

NKA/INF: INFORMATION TECHNOLOGY FOR ACCIDENT AND EMERGENCY MANAGEMENT

The development in time and the substance of the project may be found in reference 1.

In the main phase a detailed scenario analysis has been performed together with a conceptual analysis of dynamic decision making. Great efforts have been put into the detailed study of the basic functions of information flow, in emphasising the most important centres - the County Emergency Organisation Centre (County EOC), the National Institute of Radiation Protection, and the National Power Inspectorate for the off-site organisation, Plant Emergency Manager for the on-site organisation - and in trying to identify the type of information transferred between different operational functions in the main centres, see Figure 1. From this analysis data and knowledge required to develop an effective decision support system have been specified.

This has been performed for the off-site and on-site organisations separately, and has been presented in more detail in references 2 and 3.

The aim of the project is not to develop a complete decision support system to cope with all aspects of emergency situations, but to develop prototype systems to support decision making in limited parts of emergency situations.

In total, four different experiments will be performed based on

four different scenarios, two on-site and two off-site, and correspondingly, two prototype systems will be developed - one for on-site and one for off-site - to support decision making in these situations. The results obtained in using the prototype systems will be compared with drills using "normal" procedures to demonstrate the advantage of the system. All scenarios shall demonstrate detection, diagnosis, formation of plan of action, and execution.
The experiments will provide us with material for empirical evaluation of the combined effect of the implementation strategy, the conceptual model for the developed part of the decision support system, and the use of data/knowledge bases.

Evaluation of the Decision Support System

Evaluation of a decision support system (DSS) may proceed along two lines. The first line involves an analytical evaluation, the second an empirical evaluation.

The analytical evaluation may be seen as a normative theory that specifies the steps necessary for a good decision. The decision maker starts by implementing some plan, notices the consequences using the DSS, and evaluates them in terms of expectations. Finally, a decision is made as to whether the result is acceptable or not, including the kinds of displays provided, and the knowledge required for understanding the displays.

An empirical evaluation is desirable as well, as there are some aspects of the evaluation problem that cannot be solved analytically.

Two main questions for an empirical evaluation are:

- Will the DSS actually be used?

- When the DSS is used, will the decision be better than when it is not used?

The first of these questions can only be evaluated in the context of a total system, where different systems compete for the decision maker's attention. This is outside the scope of the Nordic project, but will be valid for the European project. The second question may be answered for limited-part prototype systems, but for the evaluation to be beneficial, one should be careful not to involve systems or decisions not using the DSS which is being evaluated.

In the empirical evaluation mainly two functions will be considered:

- A message handling function, designed to help the user achieve a good overview of the status, and

- A reminder function designed to ensure that all of the items in the emergency preparedness guide/plan are carried out.

Figures 2 and 3 show the schematic set-up of the experiment and an example of the man-machine interface represented by a screen dump, respectively.

The evaluation will be based on the quality of status reports produced by the persons carrying out the experiment and on the extent to which they actually carry out the items in the emergency preparedness guide/plan. Furthermore, the evaluation will be based on data on user satisfaction, unveiled by interviews of these persons after performing in a condition with the system and in a condition without the system.

ESPRIT2: IT SUPPORT FOR EMERGENCY MANAGEMENT - ISEM

For the time being only the first phase of the project concerning the conceptual model has been launched. Some preliminary ideas about the model will be given.

The definition of an industrial emergency management system is a system coping with situations involving a well defined source of accidents and a risk of release of toxic material to the environment. In this case the accident may - depending on the severity - evolve from the given location into the total on-site area, the off-site local environment, the national environment, or even into the international environment. Concurrently with the evolvement of the accident, the organisation needed to cope with the accident will become active. This is demonstrated in Figure 4 showing the development in time of the organisational set-up of emergency management in industrial plants.

It is important to realise that the given organisational model is a generic model, which means that some of the boxes displayed in the model may - for a given application - be empty. Similarly, in other applications further boxes may be needed and added to give the full description of the actual organisation.

We have found that the organisational set-up of emergency management in process industries, exemplified, as in Figure 4, by nuclear power plants (NPPs), is characterised by

- the goals involved: economic operation, plant integrity, and public protection,

- the extent of authority involved concerning: on-site, off-site, and national.

In the following paragraphs these characteristics will be further elaborated:

<u>The goals:</u>
Stated at the top of the representation shown in Figure 4.

The shaded areas of the horizontal goal bars represent the currently active goal. This does not mean that the overall importance of the goals changes in time; it means that relatively more resources and attention are required to secure the currently active or the currently highest priority goal. So, for instance, protection of the public is of greater overall and long-term importance than protection of a building of, e.g., a nuclear power plant. Nevertheless, at a given time during an emergency the NPP's emergency management organisation may be quite rational in devoting much greater effort to protecting the building - merely because the goal of maintaining protection of the public is not threatened at that stage.

The meaning of the distinction between passive and active protection of the public is the following:

Passive protection is the situation in which the public is not actively involved, but is protected by actions of the emergency management organisation.

In the active protection phase the public is actively involved by, e.g., orders to go inside, close their doors and windows, and listen to the radio. In a more severe situation the public will receive instructions for an evacuation.

The reason for distinguishing between the active and the passive protection phases is that in the latter phase there is an enlarged risk of people reacting in a non-rational way.

The extent of authority:
Indicated on the vertical axis of the representation shown in Figure 4.

As the legend explains, the double-lined boxes are the units that at a given stage have the responsibility and authority within their "area" - either on-site, off-site, or nationally.

The following contains an illustration of the extent of authority combined with the escalation of activity among the units during a nuclear emergency, see Figure 4:

- In a normal situation the only active organisational unit is the control room staff, and the goal to be focused upon is the economic operation of the plant. During normal operation the process will be watched constantly by monitoring specific critical parameters.

- If one of the parameters indicates an abnormal situation, the shift supervisor may be called and the responsibility will be passed to him. If needed, further technical expertise and managerial support from the plant owners' organisation may be brought in from outside the plant.

- If the situation evolves in an uncontrolled manner, a site emergency management will be organised for an on-site emergency situation. Furthermore, the off-site local EOC will be notified. This centre will be responsible for the local off-site situation, while the responsibility for the operations at the plant still rests with the technical management of the plant. During shift from one organisational set-up to the next, the goal to be focused upon may shift from economic operation to plant integrity.

- If there is any risk of adverse consequences outside the plant as, for instance, toxic release, the emergency situation will change from site emergency to general emergency. In the general emergency situation the organisation will develop concurrently with the evolvement of the accident corresponding to the different columns in this phase. In this case the local EOC will build up an off-site organisation calling the necessary agents such as police, fire brigade, meteorological advisory service, etc. The first action of the local EOC will be to assess the current state of the plant as well as the local off-site environment, i.e., weather conditions, population distribution, etc. In this situation the goal to be focused upon will change from plant integrity to public protection - divided into passive and active protection, respectively, as explained above.

- The last column of the organisational chart indicates the recovery phase where the shift in goals means the return from focusing on the highest goal via the next, ending with the economic operation as the focused goal in the recovery situation.

<u>Identification of General and Specific Functions</u>

Each of the columns corresponds to a specific organisational set-up or configuration. So, at each stage of the emergency (at each column of the organisational chart) the entire emergency organisation has to fulfil the following general functions (or "general tasks"):

- Assessment of the current state and current prognosis for the plant/environment.

- Assessment and possible revision of the current priority of overall goals (which goals require relatively more attention and resources now?).

- Assessment of the need for additional actions and agents: the decision to alert additional agents or organisational units.

- Establishment of communication links with units and agents.

- Distribution of tasks and co-ordination of information needed to relevant units and agents.

These general functions may be seen as methods for the entire present organisation to define specific functions for each part (unit) of the organisation. This means that at a given time the specific functions will support the fulfilment of the general functions.

Furthermore, the general functions will be means to decide the shift from one level of activity to the next. Generally speaking, the decision that additional units/agents are needed means that the next column of the organisational chart is entered. This may shift the currently focused goal, and may shift the responsibility to a new unit.

Since the units and agents needed have been defined through these decisions, the next step is to supply them with the tasks and information to perform proper actions. The most important support offered by the emergency management organisation is the supply of relevant information to the relevant agents. Therefore, the next task is to establish communication links corresponding to the current organisational configuration. In doing this, it is necessary to discuss the information flow among the different units in the model at different levels of depth.
Besides the communication tool, each organisation needs to have tools corresponding to the user requirement of the current situation. Such tools will be available from an application generator that will contain a set of tools to support functions needed in the actual situation.

Information flow among different units in the model at different levels of depth as well as development of the framework of an application generator are items being considered carefully for the time being in the ISEM project, and will be reported at a later time, see reference 4.

Conclusion

In conclusion, it is important to point out that the organisational model developed serves three purposes: First, it is intended to represent explicitly, when filled out in detail, the concrete emergency management organisational set-up and the escalation of emergency management activity for a particular plant. Second, it is intended to be used as a means of identifying the general and specific functions which each organisational unit must fulfil during an emergency. Third, it is intended to be used as a stepping stone towards representing the required flow of information among units at different stages of an emergency.

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FIGURES

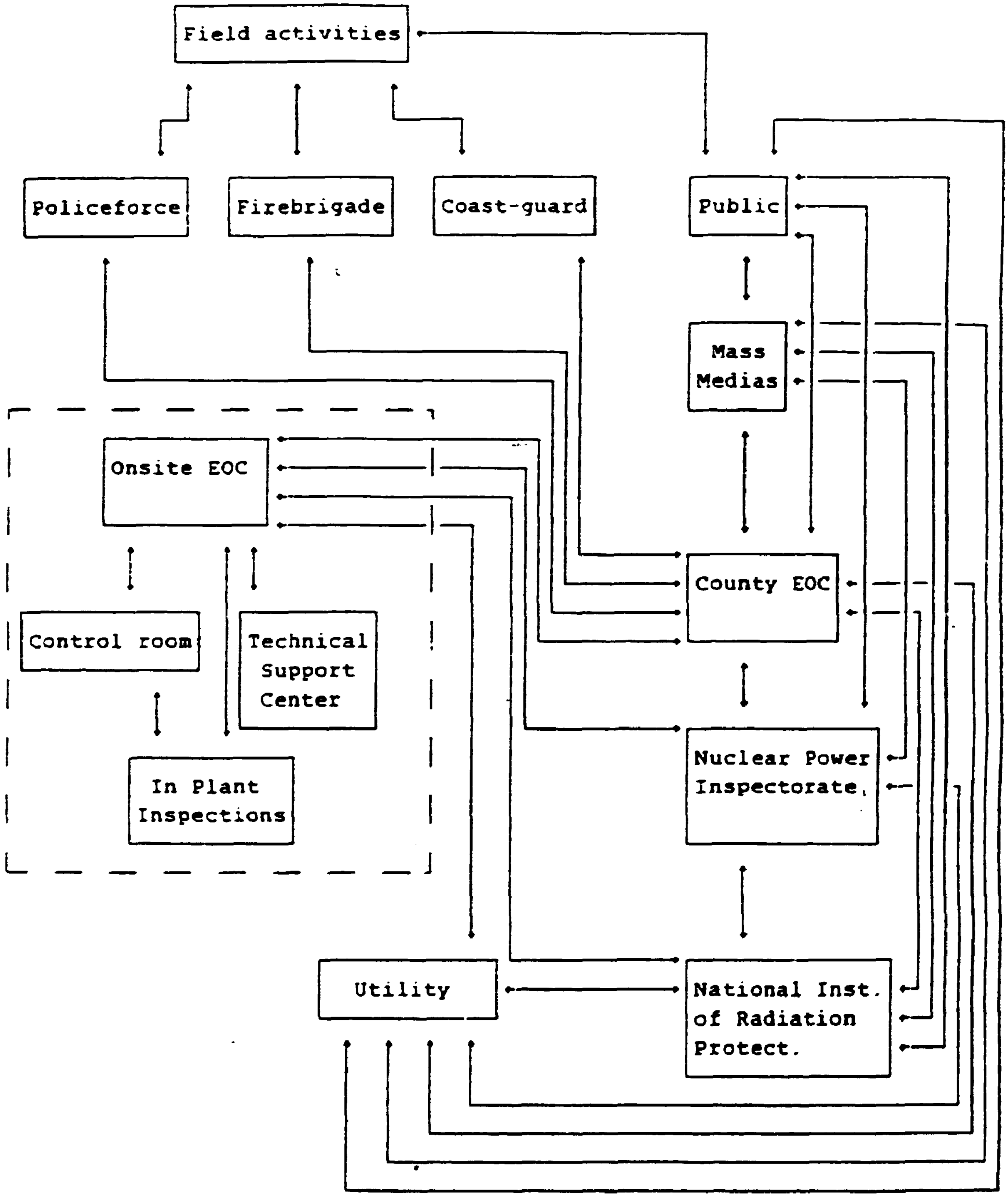

Figure 1. The flow of information between onsite and offsite participants in an emergency situation.

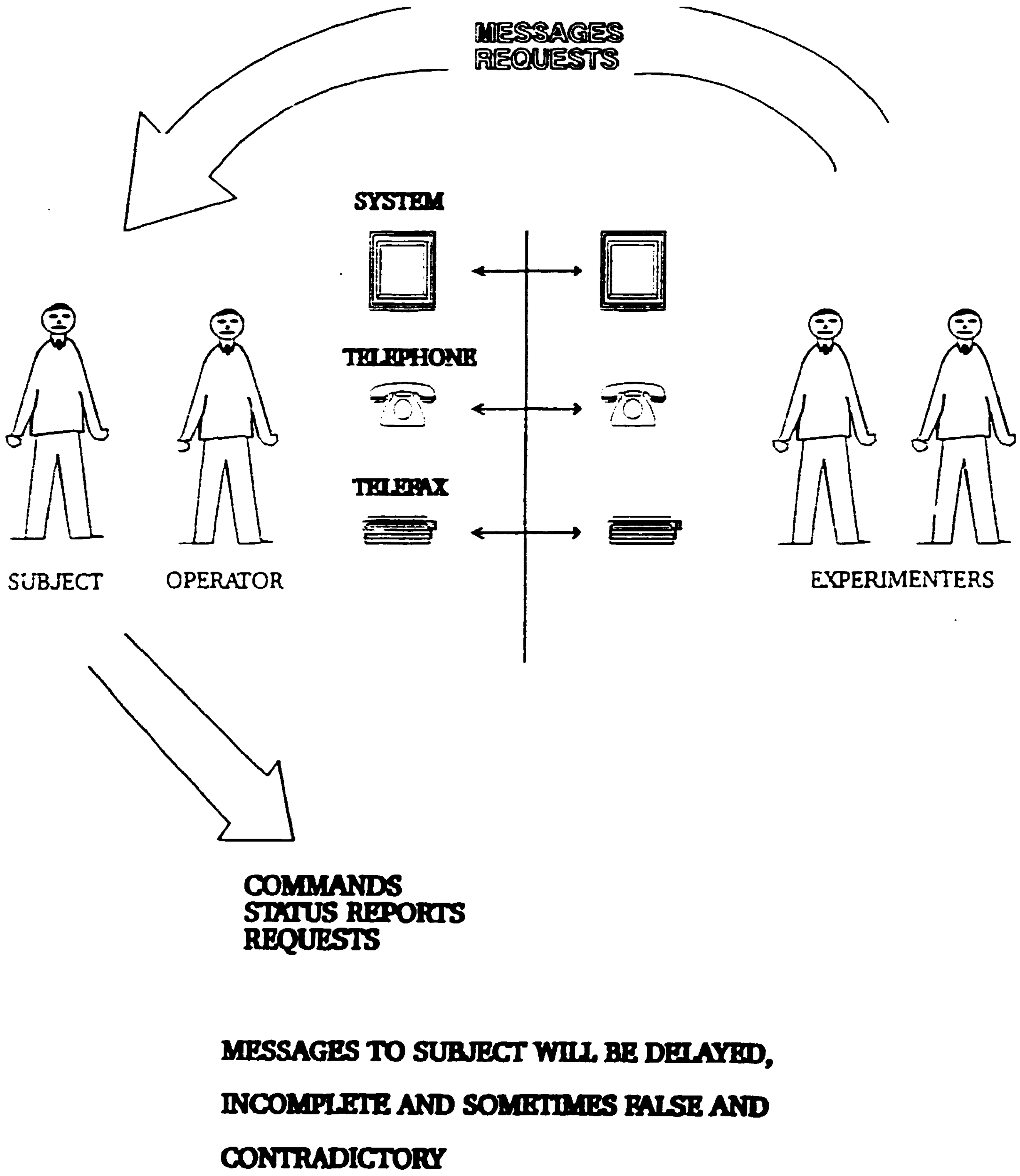

Figure 2. Schematic set-up of experiment.

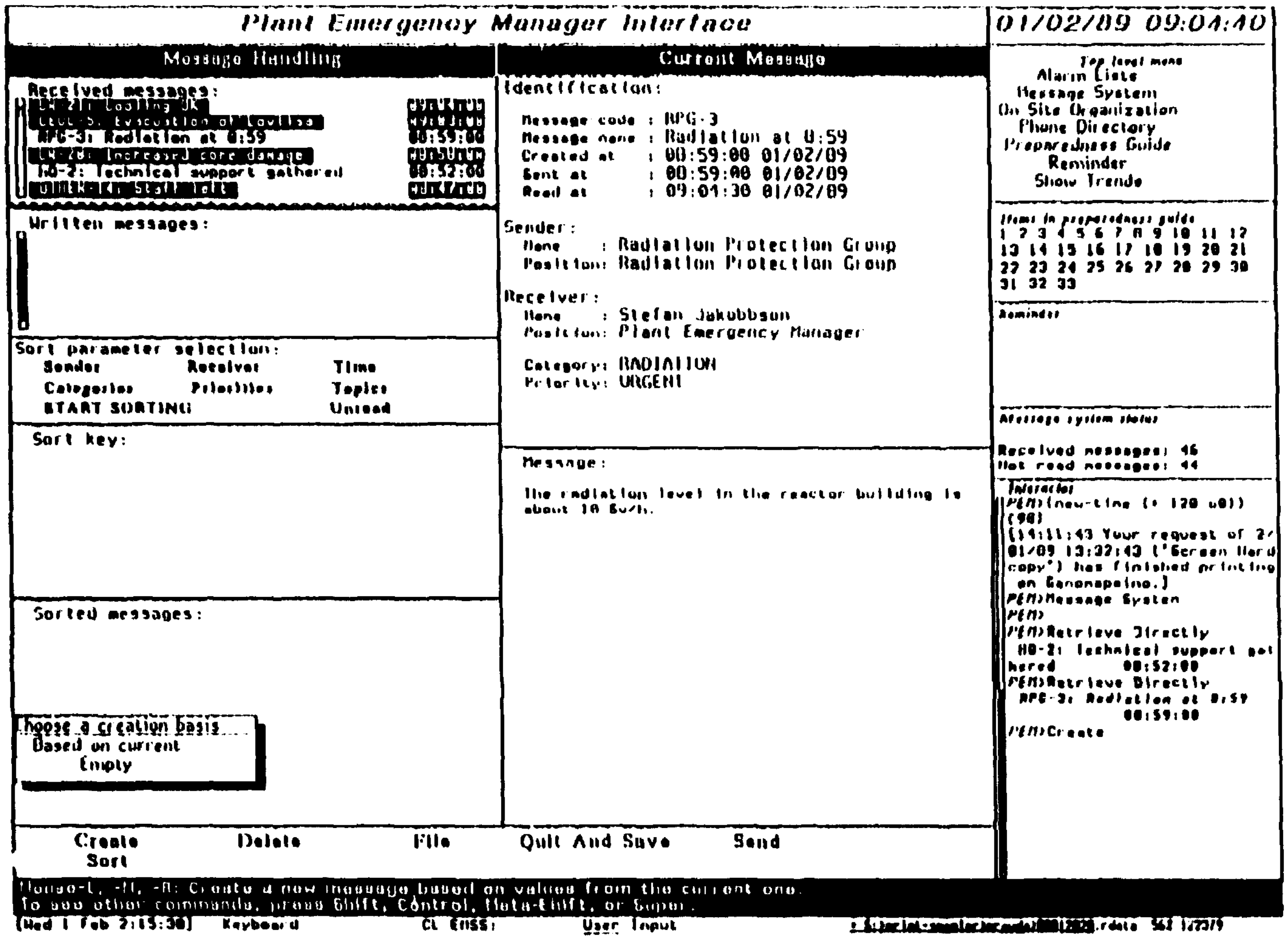

Figure 3. Example of screendump.

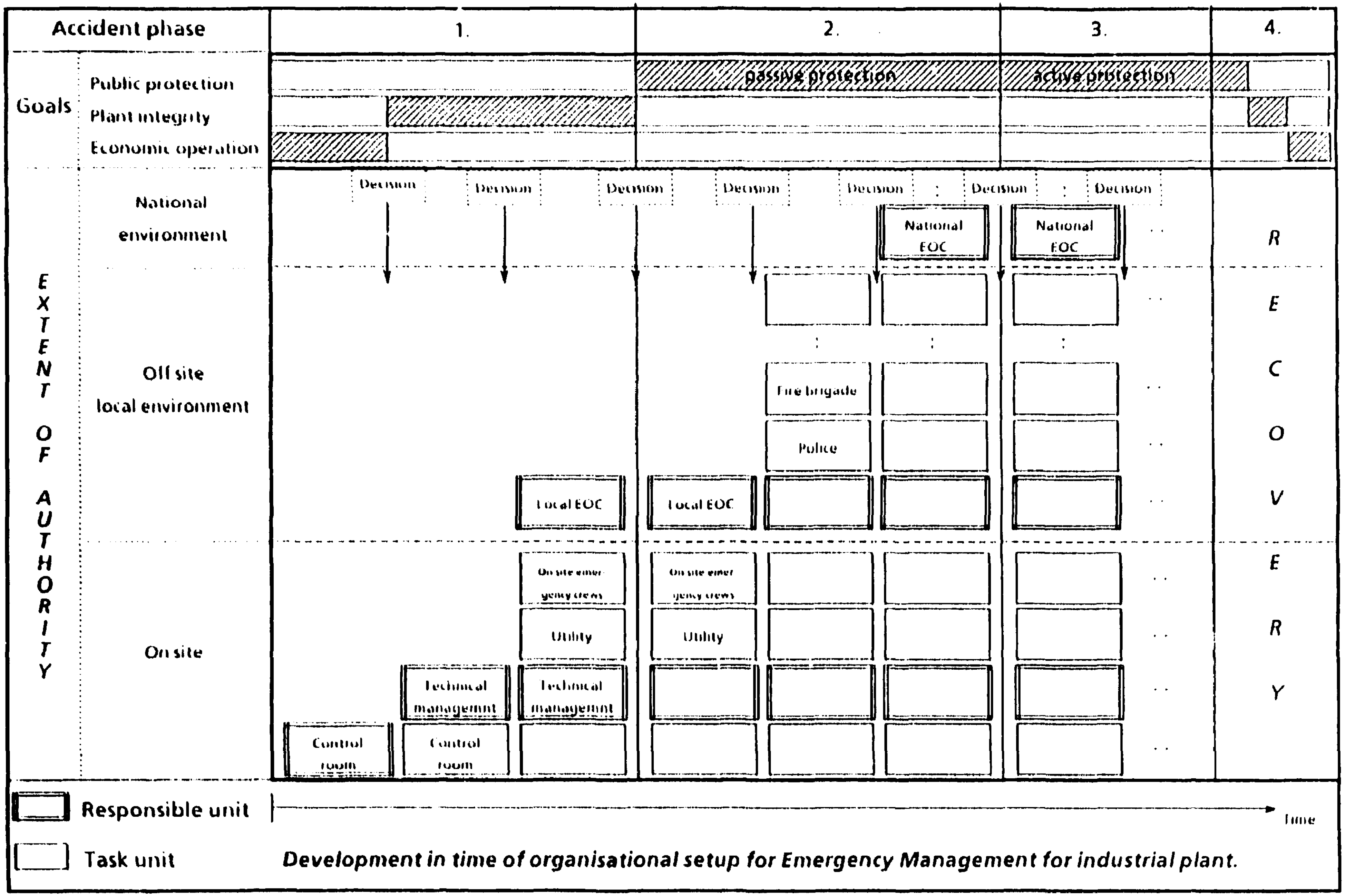

Figure 4. Organisational model in process industry.

Title and author(s)	Date May 1989
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Descriptors

Descriptors - INIS:

DECISION MAKING; EMERGENCY PLANS; EUROPEAN COMMUNITIES; INFORMATION SYSTEMS; ORGANIZATIONAL MODELS; PROGRESS REPORT; RESEARCH PROGRAMS; SCANDINAVIA

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